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Determining the Impact of Autobiographical Experience on "Meaning": New Insights from Investigating Sports-related Vocabulary and Knowledge in Two Cases with Semantic Dementia

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Determining the Impact of Autobiographical Experience on "Meaning": New Insights from Investigating Sports-related Vocabulary and Knowledge in Two Cases with Semantic Dementia

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Snowden, Griffiths, and Neary (1994, 1995) have proposed that autobiographical experience helps to maintain the integrity of semantic memory in patients with semantic dementia. We investigated this hypothesis by testing knowledge related to golf and bowls in two case studies. If Snowden and colleagues' hypothesis is correct, our two patients should have better semantic knowledge for the sport that they regularly experience, compared with knowledge of other sports. In keeping with Snowden et al's hypothesis, we found that autobiographical experience influenced the ability of the patients to match up a surname with a first name: The names of personally and currently relevant golf/bowls partners were more likely to be matched correctly than such personally relevant names from the past, or the names of famous sports celebrities. Unlike Snowden et al., however, we found that *knowledge* of people, in all categories, was severely impoverished and that any semantic information was produced as part of an

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autobiographical memory. Likewise, detailed study of each patient's under-standing of their favourite sport revealed no significant effect of autobiographical experience on true semantic knowledge. We propose that the ability of semantic dementia patients to encode, albeit temporarily, recent autobiographical memo-ries via a spared hippocampal complex supports the production of highly auto-biographically constrained semantic-like facts and, to a lesser extent, frequently encountered names. There is, however, no direct effect of autobiographical experience on previously established semantic memory, i.e. knowledge of golf, bowls, and people, presumably stored within the temporal neocortex. These results are discussed with respect to current anatomically based computational models of long-term memory.

INTRODUCTION

The work presented in this paper is an investigation into the effect of autobio-graphical experience on person-specific and general semantic knowledge in patients with progressive loss of semantic memory. It follows on from two published studies, by Snowden et al. (1994, 1995), in which they proposed that current autobiographical experiences help maintain the integrity of semantic knowledge in patients with semantic dementia. Here, we present the results from a number of experiments, performed by two patients with semantic dementia, which investigate the integrity of semantic knowledge for two sports: golf and bowls. The results are discussed with respect to Snowden and col-leagues' hypothesis and to current computational models of long-term memory.

The term semantic dementia was first coined by Snowden, Goulding, and Neary (1989) to describe patients with a progressive loss of semantic memory (see Hodges, Graham, & Patterson, 1995; Hodges, Patterson, Oxbury, & Funnell, 1992). Semantic memory is our store of knowledge about objects in the world, concepts, facts, and the meanings of words (Tulving, 1972). It plays a crucial role in a range of cognitive tasks: Patients with semantic dementia have progressive problems with word-finding, understanding spoken and writ-ten language, and performing word- and picture-based tests of semantic knowl-edge, such as the Pyramid and Palm Trees test (Howard & Patterson, 1992), as well as reading and writing. Other nonsemantic cognitive abilities such as visuo-perceptual and spatial skills, nonverbal problem-solving, auditory-verbal short-term memory, and the syntactic and phonological aspects of speech are unaffected by the disease, at least for a significant period of time after the patient presents (Hodges et al., 1995; Hodges & Patterson, 1996; Hodges, Patterson, & Tyler, 1994).

In contrast to the detailed investigation of the nature and impact of semantic memory breakdown, episodic memory has been investigated relatively little in these patients. Tulving (1983, p. 21) proposed that episodic memory "is a system that receives and stores information about temporally dated episodes or events, and temporal-spatial relations among them." He also believed, at that

time, that episodic and semantic memory were functionally distinct, but recognised that there was a need for further studies of the relationship between the two types of memory. Many patients with semantic dementia appear to possess relatively "normal" memory for recent events (Diesfeldt, 1992; Graham, Becker, Patterson, & Hodges, in press; Hodges et al., 1992). Until recently, there had been only four studies of episodic memory in semantic dementia: Warrington (1975) showed normal forced-choice recognition memory of paintings, but poor recognition of words and unfamiliar faces in three patients; Diesfeldt (1992) demonstrated normal new learning using a forced-choice recognition memory test in a single case; Snowden et al. (1994) initially demonstrated better semantic knowledge of currently relevant people and places in five patients, and subsequently, in 1995, showed that a single patient had preserved, but autobiographically constrained, knowledge of unusual words in frequent use in her vocabulary.

The results from these studies are intriguing: On tests of new learning, some patients showed normal recognition memory whereas others did not, suggesting that performance is affected by the type of material to be learnt (especially verbal vs. nonverbal). With respect to autobiographical memory, there seems to be a crucial impact of recent experience on the integrity of semantic memory, to the extent that patients have better knowledge about people and places who are currently relevant (compared to those relevant in the past) and can produce unusual, low-frequency words related to current experience appropriately in spontaneous speech. In this paper, we will investigate the nature of the impact of autobiographical experience on semantic knowledge.

One problem with Snowden et al.'s (1994) study was that the patients were tested on highly familiar person- and place-specific vocabulary, as opposed to more general semantic knowledge (i.e. factual knowledge about objects and the meaning of words). If Snowden et al's hypothesis is correct, autobiographical experience should also benefit general semantic knowledge, but this aspect was not explored in their paper. Although the cognitive and neural fractionation of different domains of semantic knowledge is a controversial topic, there is accruing evidence for the separation of person-specific, as opposed to more general, semantic knowledge (Greene & Hodges, 1996; Hodges & McCarthy, 1995). For instance, the three patients that have been described with relatively isolated loss of person-specific semantic knowledge (Ellis, Young, & Critchley, 1989; Evans, Heggs, Antoun, & Hodges, 1995; Hanley, Young, & Pearson, 1989) all had right temporal lobe (especially the temporal pole) pathology. By contrast, patients with semantic dementia have atrophy involving predominantly the left infero-lateral temporal gyri, with sparing of the hippocampal complex that appears in some cases to be confined to the left side, suggesting that left-lateralised temporal neocortex may be crucial for more general semantic knowledge (Graham, Becker, et al., in press b; Hodges & Patterson, 1996; Hodges et al., 1992). It is not evident, therefore, from Snowden et al.'s (1994)

study whether more general semantic knowledge, like person-specific semantic knowledge, would benefit from autobiographical experience, yet Snowden et al. (1995, p. 243) conclude, "We would argue that autobiographical experience is a potent factor in influencing preserved knowledge in semantic dementia."

The second, and more theoretically challenging, problem with Snowden et al.'s hypothesis concerns the fact that, at the time of publication of their studies, there had been no studies concentrating on autobiographical memory per se in patients with semantic memory loss. Our recent studies have demonstrated that both autobiographical and semantic knowledge are better preserved in the current time-period compared to the distant past (Graham & Hodges, 1997): Six patients with semantic dementia were better at retrieving autobiographical memories from the most recent few years compared with similar memories from their early adulthood and childhood (as tested using the Autobiographical Memory Interview; Kopelman, Wilson, & Baddeley, 1990; Greene, Hodges, & Baddeley, 1995). A detailed single-case study confirmed the results from the group study, and revealed that memories for only a short period of time (2 years prior to time of testing) were preserved (Graham & Hodges, 1997). A more recent study of person knowledge in semantic dementia revealed a similar result: Five patients showed a time-based effect (current better than distant) in recognition and identification of famous names (Hodges & Graham, in press). Four of these patients showed better recognition of famous names from the current time-period (1995–1996), yet were unable to provide identifying information about any of the 120 famous names in the test. Another patient, DM, who had a milder impairment to semantic memory, was much better at providing detailed information about people from the current time-period than any of the other three time-periods (1950s, 1980s, and 1990–1994).

The results from these two studies were interpreted with respect to current anatomically based computational models of long-term memory (Alvarez & Squire, 1994; McClelland, McNaughton, & O'Reilly, 1995; Murre, 1997). These models suggest that the hippocampus and related structures are crucially involved in the temporary storage of recently experienced memories. Over time, these memories become independent of the hippocampal formation and are stored, as permanent representations, in the temporal neocortex. These computational models explain why semantic dementia patients, with a spared hippocampal system and atrophied temporal neocortex, are able to encode new autobiographical memories, and why both autobiographical and semantic memory were impaired when the patients were tested from more distant time-periods, such as childhood, middle-age, etc. (Graham & Hodges, 1997).

The results from the studies discussed here suggest that autobiographical experience and semantic knowledge in the *recent* time period are highly interlinked (i.e. all "recent" knowledge is autobiographically constrained). As proposed by McClelland et al. (1995), autobiographical, semantic, and encyclopaedic information are all acquired via synaptic changes in the hippocampus

and are only distinguishable as different types of memory when they are encoded permanently in the temporal neocortex. There is evidence to support this in Snowden et al.'s (1995) study. A patient (WM) produced definitions to nouns (oil, field, etc.) and noun phrases (oil field, etc.) drawn from her conversational vocabulary. Snowden et al. (1995, p. 240) comment, ". . . her definitions had a markedly autobiographical quality. Despite encouragement to expand her definitions she rarely provided information that went beyond her own direct experience." In fact, from the examples in this paper, all WM's definitions were autobiographical. WM was deriving semantic information in the only way available—by recalling an autobiographical experience. For example, to the world "field," WM responded (op cit., p. 240), "I walk round the field with the vicar's dog." To the word dog, she replied (op cit., p. 238), "They're out there (referring to dogs barking outside). I take the vicar's dog for a walk at 2 o'clock."

It seems, therefore, that Snowden et al.'s tests were measuring the ability of their patients to produce autobiographical information (i.e. information that has a temporal and spatial quality) rather than more generalisable semantic facts. Snowden et al. (1995, p. 241) propose a similar explanation, commenting, "She (WM) appears to have no general knowledge of oil that extends beyond her personal experience, and is unable to conjecture what an oil field might be." Yet they conclude (op. cit., p. 241).

Autobiographical experience appears to have a direct effect in determining what information is available and what is lost . . . Findings from the present study suggest a much more interactive relationship between semantic memory and autobiographical experience: a dynamic semantic memory system that is constantly updated with information from personal experience.

We believe that there is no evidence in Snowden et al.'s (1994, 1995) studies to support the theoretical conjecture that the semantic memory system is constantly updated with autobiographical information. Snowden et al. have failed to take into account the fact that *recently* learnt (hippocampally dependent) and *previously* learnt (neocortically dependent) semantic knowledge may be differentially dependent upon autobiographical memory. The aim of this study was, therefore, to address the issue of whether previously learnt (neocortically dependent) semantic knowledge benefited from autobiographical experience.

To test whether patients with semantic dementia do show an effect of autobiographical experience on previously learnt semantic knowledge, we compared the performance of two patients on a number of tests based on golf and bowls. These two sports were selected because the two patients were playing one of these sports each week. The tests investigated knowledge of the relevant sport (and some other sports) and the ability to recognise names and

provide person-specific knowledge about sporting friends and famous sporting celebrities. These tests were designed to be similar to those used by Snowden et al. (1994). We predicted, based on clinical observations from a number of our patients with semantic dementia, that there would be no effect of autobiographical experience on the two patients' knowledge of sport.

SUBJECTS

Two patients with semantic dementia (AM and MS) took part in this study. At the time of testing, AM was 65 years old and MS was 74 years old. On the semantic battery their performance is compared to that of 24 age-matched controls chosen from the Applied Psychology Unit's subject panel (see Hodges & Patterson, 1995). For the experimental components of this study, a number of control subjects were given the tasks designed to test semantic knowledge of golf and bowls (golf: four men, average age = 70.7 years, SD = 6.3; bowls; four women, average age = 71, SD = 5.4). The golf controls had been playing for an average of 32.7 years (SD = 11.7) and had also played a number of other sports (particularly tennis and football—like AM). The bowls players had been playing for 13.5 years (SD = 11.6) and two had played tennis in their teens. Overall, none of the controls had any significant difficulty with these tests, despite three of the items used in the bowls test being related to crown bowls (played by MS), which is not played in Cambridgeshire. Both spouses were also tested: They performed at ceiling on the tests of sporting knowledge and confirmed that all the words were familiar to MS and AM before the onset of their illness.

AM

AM (d.o.b. 1930), a right-handed ex-company executive, presented in April 1994 with features of semantic dementia. He has been previously reported in papers by our group (Graham & Hodges, 1997; Hodges & Patterson, 1996). His wife had noticed problems with word-finding over the last 5 years, especially for nouns, and more recent difficulties with comprehension. AM, a highly motivated and bright man, had been practising lists of nouns during this time. Examination of these lists show clear evidence of surface dysgraphia (for example, he had written "trawley" for "trolley", "sealings" for "ceilings"). When he first presented, AM was severely anomic: He could only name 3 out of 48 items in a picture naming test (based on the same black-and-white line drawings in the Hodges semantic battery). Category fluency was equally impaired—he was unable to produce any exemplars for three categories out of eight (four living and four manmade). On tests of comprehension AM showed moderate impairment. On the word–picture matching test from the semantic battery, he scored 36/48 (controls 47.4, SD = 1.1) and on the three-picture

version of the Pyramid and Palm Trees test of semantic association he scored 39/52 (controls 51.2, SD = 1.4; Howard & Patterson, 1992). Since 1994, AM has shown a relentless decline in comprehension: in October 1995; he scored 13/48 on the word–picture matching test mentioned above (see Table 1) and 7 months later, in May 1996, he was only able to match 8/48 items (chance = 1/8). His picture naming has similarly declined: AM named six black-and-white line drawings (out of 48) in October 1995, but by May 1996 was unable to name any. By contrast, his ability to draw complex figures (e.g. the Rey Figure; Osterreith, 1944), and to perform nonverbal problem-solving tests, such as Raven Coloured Matrices (Raven, 1962) remained within the normal range (see Table 1). It should be noted that although AM's recall of the Rey Figure was below normal in May 1996, this impairment was not as profound as any decrement on tests of semantic memory.

AM's comprehension difficulties have had a considerable practical impact. For example, AM was reported to have eaten a fillet of defrosting raw salmon, accompanied by some yoghurt, thinking that it was dessert. On another occasion, when given an umbrella during a rain-storm, he placed it horizontally over his head, but failed to open it up. Furthermore, he was surprised when his wife

TABLE 1
Performance of AM, MS and 24 Control Subjects (see Hodges and Patterson, 1995) on a Range of Neuropsychological Tests

Tests	AM October 1995 (May 1996)	MS	Controls (n = 24) Mean (SD)
Semantic Memory			
Word–picture matching (out of 48)	13 (8)	15	47.4 (1.1)
Cat. fluency—living (4 categories)	0	1	58.3 (12.3)
Cat. fluency—manmade (4 categories)	0	2	55.4 (8.6)
Picture naming (out of 48)	6 (0)	0	43.6 (2.3)
Pyramid and Palm Trees test (out of 52)	32 (25)	NT[a]	51.2 (1.4)
Episodic Memory			
Rey Figure—Recall (out of 36)	6.5 (9.5)	10	15.2 (7.4)
Visuo-perceptual Skills			
Copy of the Rey Figure (out of 36)	35 (35)	36	34.0 (2.9)
Problem solving			
Raven's Coloured Matrices (out of 36)	30 (33)	33	NT

[a]MS was unable to grasp the concept of the Pyramid and Palm Trees test (Howard & Patterson, 1992). On a similar, easier, test from the Birmingham Object Recognition Battery (Riddoch & Humphreys, 1993) she scored 8/30.

Tests were as follows: Rey Complex Figure (Osterrieth, 1944); Pyramids and Palm Trees test (Howard & Patterson, 1992).

opened the umbrella for him. On a recent aeroplane trip (in November 1996) AM was extremely upset when his suitcase was taken away from him and could not comprehend how it was possible to get to his destination in such a short time. Over the past 12 months he has become increasingly withdrawn, uncommunicative, and time-obsessed.

For the purposes of this paper, it should be noted that AM had always been a keen sportsman (playing golf, tennis, table-tennis, snooker, squash, football, and cricket). He took up tennis in his teens and started playing golf, as a substitute for squash, in his early 50s. When playing at his best, AM had a golf handicap of 10 and, by all reports, was a formidable opponent who successfully competed in (and won) a number of competitions. Since the onset of his illness, AM has been playing golf at least four times a week (all year round) and tennis once a week (in the summer months). AM's ability to play golf has deteriorated only slightly over the past 2½ years: In fact, his wife is still consistently frustrated by his "good touch." His handicap has, however, declined and AM often fails to follow the rules of golf. For example, he now removes his ball from bunkers, swears when he makes a poor shot, and plays out of turn (or ahead of his partners). His wife is adamant that, despite his comprehension difficulties, he manages (on most occasions) to select the correct club for the conditions. In November 1996, AM scored at chance on word–picture matching tests of golf, tennis, and snooker and also failed to recognise a colour picture of a golf course; responding, "I've never had to do with that."

MS

MS was born in 1921. She attended school until 14 years and then worked as an office clerk. She married in 1942, had one child and continued work on a part-time basis. MS first presented in 1994 with a history of gradual word-finding difficulties. At this time, her spouse reported that her anomic problems were accompanied by difficulties in understanding written and spoken language. She was not formally tested, however, until 1996, when her husband confirmed that her word-finding and comprehension problems had become much worse. She was also impaired on the picture–picture association subtest of the Birmingham Object Recognition Battery (Riddoch & Humphreys, 1993), a test that is similar to the Pyramid and Palm Trees test (Howard & Patterson, 1992). Like other reported cases of semantic dementia, MS showed sparing of other cognitive functions (see Table 1). For example, MS's spontaneous speech was fluent with no phonological or syntactic errors, although it should be noted that she was marginally impaired on the Test for the Reception of Grammar (Bishop, 1989). She was able to copy the Complex Rey Figure (Osterreith, 1944), and her forwards digit span (7) and performance on the Raven's Coloured Progressive Matrices (Raven, 1962) was normal.

MS's speech was fluent with obvious word-finding difficulties, but with no phonological and syntactic errors. She was unable to name any pictures from the picture naming component of our semantic battery (Hodges & Patterson, 1995). She was also profoundly impaired on category fluency, producing three exemplars across all categories. She had a severe comprehension deficit: On the Hodges' word–picture matching test, she scored 15/48 and was clearly impaired on similar tests from the PALPA (spoken: 16/40 and written: 18/40; Kay, Lesser, & Coltheart, 1992). MS was also surface dyslexic: On a set of 84 low-frequency words MS was able to read all of the regular words correctly (42/42), but made regularisation errors to 13 exception words (29/42). Despite her profound difficulties with language, she had an active social life and could accurately recall past and future events without the aid of her diary.

The patient and her husband have been playing bowls for the last 12 years. At the time of testing, they were playing two or three times a week throughout the year (i.e. indoor bowls in winter, outdoor bowls in summer). MS is an extremely successful bowls player, who has played in club and county teams.

An edited transcript of a conversation about bowls is shown below (from 30/7/96). The full version is shown in Appendix A. This was a conversation about bowls between Matt Lambon-Ralph (E), MS, and MS's husband (R).

E: What do you do first?
MS: Well you start
(*R*: You put a mat down)
E: Right, so you put a mat down and then what do you do?
MS: Well you send off the . . . err
(*R*: Jack)
MS: The jack, and depending on how far it has gone, mmm, the ones at the top there, mm, has got to put it exactly opposite the back bit and the front bit
E: Right. And then how many bowls do you have each?
MS: It depends what's going on. It depends what on earth you're doing.
E: Right
MS: We were down there about a month ago and, . . . err, there were two females who only had two at that time, because that was the thing that they were . . . against that day
E: So the person who is in charge, of your team, what's their name? What are they called?
MS: Don't know
(*R*: The person at the top end that centres the jack)
MS: Well, do we give them a name?
(*R*: Yes)
MS: The one at the top there?
(*R*: Mmm)
E: The skip
MS: Oh I'm sorry I thought you were talking about someone else

Two points are clear from this extract: First, MS was unable to produce any of the appropriate bowls terms (e.g. jack, end, skip, wood, rink, etc.) in spontaneous speech. Furthermore, her comprehension of these terms (when they were produced by her husband and the experimenter) was strikingly impoverished. She frequently responded that she did not understand what they were talking about and rarely provided any more semantic information when the terms were described to her. The only detailed conversation produced by MS was related to an event she witnessed a month ago when she went to play bowls. She uses the autobiographical event to provide information about the number of bowls a player may use when playing. Yet she does not seem to have any knowledge about the circumstances in which a player would use different numbers of woods. In summary, her knowledge of bowls, at least with respect to the section of spontaneous speech above, was noticeably impaired. By contrast, her husband clearly understood what the terms meant and could converse with the experimenter about aspects of the game.

Neuroimaging

Figure 1 shows comparable coronally oriented MRI scans for AM (top) and MS (bottom). AM's scan, which was taken in October 1994, shows focal bilateral infero-lateral temporal lobe atrophy, with the left temporal lobe being much more affected than the right. The hippocampus and parahippocampal gyrus are relatively spared.

MS's MRI scan (in 1996) shows profound atrophy of the left temporal pole with a degree of generalised atrophy throughout the left hemisphere. Although there were mild atrophic changes in the right temporal lobe, the hippocampus and superior temporal gyrus were spared (bilaterally).

EXPERIMENTAL INVESTIGATIONS

Experiment 1: Recognition of People's Names (Surname–First Name Matching)

For each patient, the names of personal sporting friends were obtained. For AM, his spouse provided the names of 10 personally relevant, current golfing friends. She also suggested the names of 5 personally relevant, current tennis friends and 5 friends with whom AM used to play tennis. We also selected the names of 10 currently famous and 10 previously famous golfers (e.g. Current: "Nick Faldo," "Colin Montgomerie"; Past: "Gary Player," "Peter Alliss"), and 10 currently famous and 10 previously famous tennis players (e.g. "Andre Agassi," "Steffi Graf"; Past: "Fred Perry," "Billie Jean King").
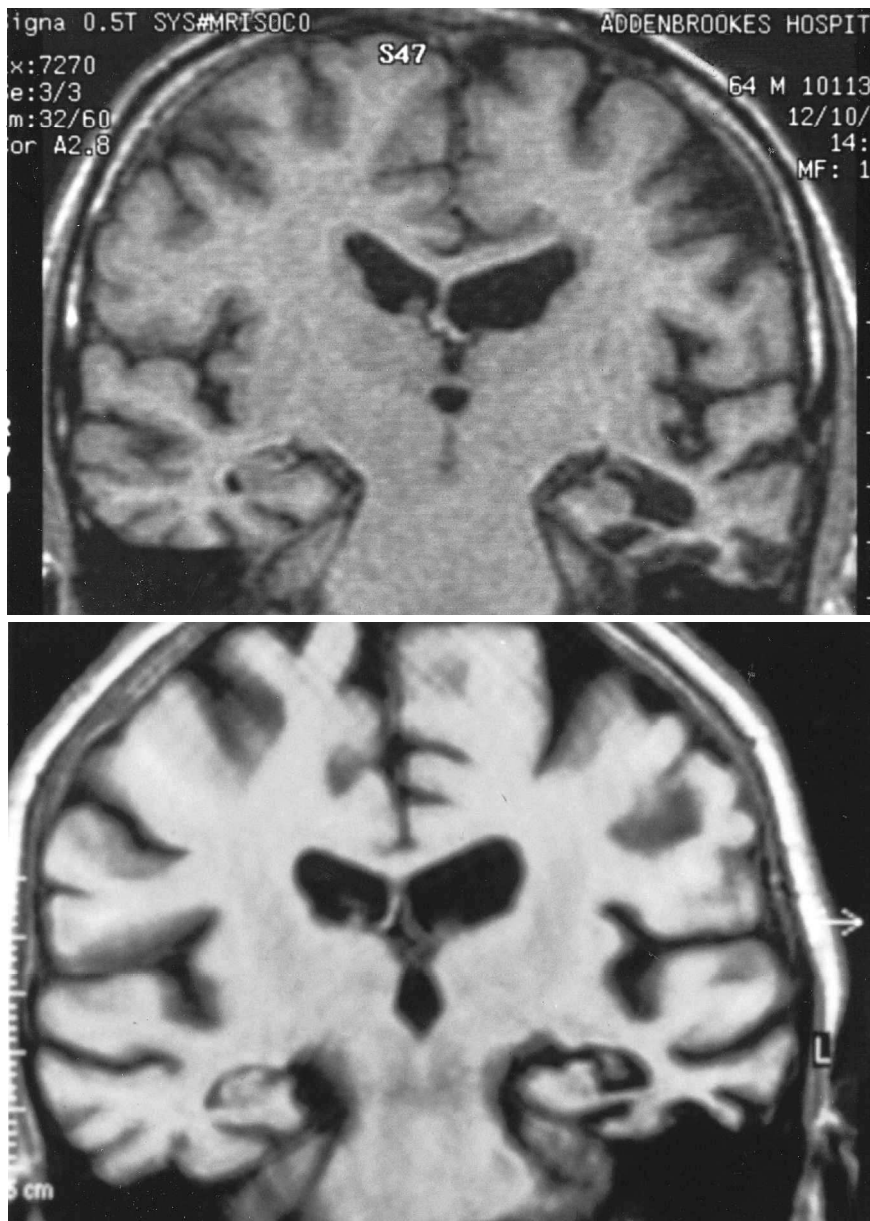
FIG. 1. Coronally oriented MRI scans for AM (top) and MS (bottom). AM's scan shows bilateral infero-lateral temporal lobe atrophy, with less atrophy on the right. There was evidence of sparing of the hippocampal complex. MS's MRI scan revealed focal atrophy of the left temporal pole with some generalised atrophy of the left hemisphere. There were also some mild atrophic changes in the right temporal lobe. The superior temporal gyri and hippocampi were preserved bilaterally.

811

A similar procedure was used with MS: Her spouse provided us with the names of 10 personally relevant friends, with whom MS was currently playing bowls. We matched these names with the names of 10 famous bowls players. It was harder to find famous bowls players than golfers, so we only used a single set of bowls players (most of whom were currently famous). MS's spouse also provided us with a set of 10 family names (MS saw some of the people daily while others were seen less often). A further set of 10 currently famous and 10 previously famous celebrities were used with MS (e.g. Current: "John Major," "Paul Gascoigne"; Past: "Marilyn Monroe," "Harold MacMillan").

Each surname was presented, in both a written and oral format, with three first names—two distractors and a target (for example, "Faldo" was presented with "Jack," "Tom," and "Nick"). We ensured that target names that were unusual (e.g. Stanley or Andre) were matched with equivalent names. The position of the target amongst the two distractors was randomised, although the number of positions (four items in position 1 and three in position 2 and 3) used in each group was the same, so that no single category benefited from a response basis. The order of presentation of the trials was random, with names of celebrities being mixed with friend and family names. Each patient was allowed as much time as possible to make their choice, and could ask the experimenter to repeat the items if necessary.

On this test, the four golfing controls correctly matched the first name with the surname of every famous (current and old) golfer and tennis player. The four control bowls players performed almost at ceiling on the famous bowls names (9.75, SD = 0.5) and showed little difficulty with the famous celebrities (Current: 10, SD = 0; Past: 9.5, SD = 1.0).

Mean scores for AM and MS are shown in Fig. 2a, 2b, and 2c. A "*" above a column in any of the figures represents a score that was significantly different from chance (as calculated using 95% confidence intervals). Figure 2a shows AM's performance on the golf names test on three consecutive occasions: in September 1995, May 1996, and September 1996. In September 1995, AM's ability to match names from the personal current golf category was significantly better than that from the famous current category (Binomial Proportion test, $z = 3.1$, $P < .01$), but not from the famous past category ($z = 1.3$, nonsignificant). Eight months later, in May 1996, the only category on which he scored above chance was for the names of golfers who were personally and currently relevant. His performance on the other two golf celebrity groups was significantly worse (Personal Current vs. Famous Current: $z = 5.5$; $P = < .001$; Personal Current vs. Famous Past: $z = 3.6$, $P < .001$). By September 1996, his score of 6/10 on the names from the personal current category was not significantly different from chance. In summary, it can be seen that, while AM's ability to match current personal golf names declined over the three testing sessions, overall he was much better at matching these names compared with famous golf names.

Figure 2b shows AM's performance on the tennis names across the three testing sessions. In September 1995, towards the end of his tennis-playing season, AM was 100% correct at matching the names of people with whom he currently played tennis. He was worse on the names for past tennis friends, currently famous tennis players and famous tennis players from the past[1]. Over time, AM showed a striking pattern. All categories were performed at (or below) chance level in May 1996, at which stage he had not recommenced playing after his normal winter recess. Four months later, in September 1996, AM's matching in two categories (personal current and famous past tennis) improved: He correctly matched 5/5 of the personal names and 7/10 of famous names from the past. By contrast, he showed no improvement on names from the personal past and famous current category.

MS showed a striking advantage for the names of her current bowling colleagues (see Fig. 2c). She correctly matched 8/10, compared with 2/10 for famous bowls players ($z = 5.4$, $P < .001$). She showed a similar advantage when tested on her family and non-bowling friends' names: She correctly matched 6/10. By contrast, she was significantly worse on the names from the currently famous and previous famous celebrity categories compared with names that were personally relevant (Personal Bowls and Family/Friends vs. Famous Past and Current: in all analyses, $z = 5.4$, $P < .001$). By combining the 10 bowls names and the 10 names for family and friends, it was possible to analyse MS's accuracy with respect to how often she sees each person. MS was only able to match 3/8 names correctly for people who she sees only once a month or less often. By contrast, she was able to match correctly 11/12 names for people she sees at least once every 2/3 weeks.

Discussion

The results from this first experiment are similar to those published by Snowden et al. (1994). In both studies, the ability of patients with semantic dementia to match a first name to a surname ("Tom," "John," or "Steve" to "Major") was affected by the current relevance of the name. AM was better at matching the names of personally relevant people with whom he currently played golf or tennis compared with famous golfers and tennis players. MS was much better at matching the names of people with whom she currently played bowls (and to a lesser extent family friends) than any of the other categories (currently and previously famous people and famous bowls players). There was also evidence that MS's performance on the name-matching test was affected by how often

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[1]Binomial analyses were not used in the tennis category for two reasons: (1) there were too few items in AM's personal categories ($N = 5$); and (2) AM performed well below the confidence interval cut-off (7/10) in all the other categories (apart from past famous tennis players in May 1996).
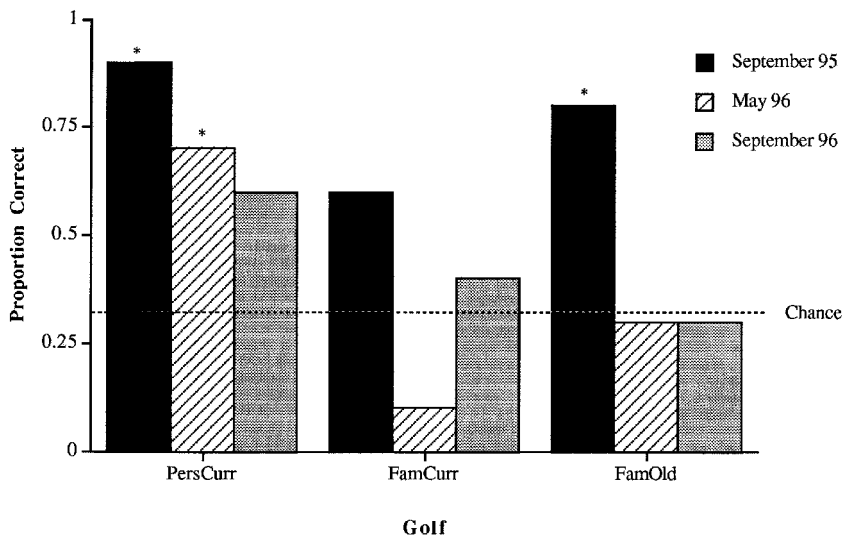
Golf

FIG. 2a.   AM's performance on the golf categories from the surname–first name matching test over time. AM was tested in September 1995, May 1996, and September 1996. PersCurr = people with whom AM currently plays golf; FamCurr = currently famous golfers (Nick Faldo); FamOld = golfers famous in the past (Gary Player).
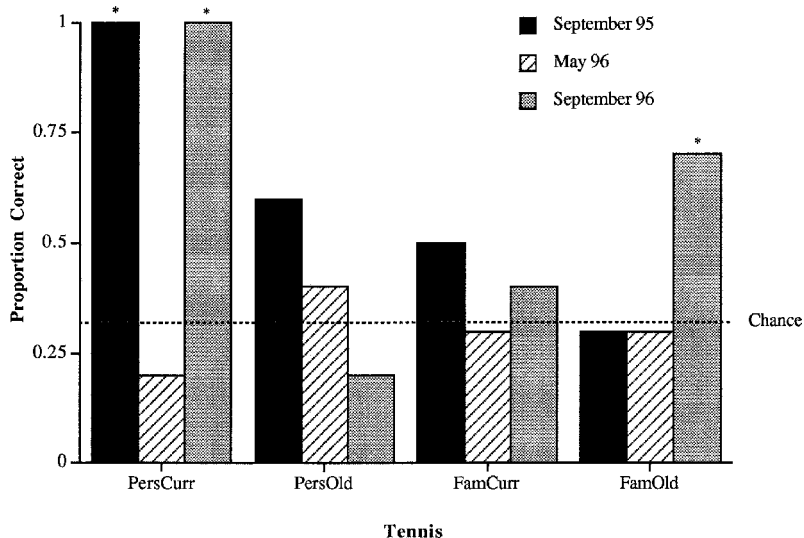
Tennis

FIG. 2b.   AM's performance on the tennis categories from the surname–first name matching test over time. AM was tested in September 1995, May 1996, and September 1996. It should be noted that AM was not playing tennis before he was tested in May 1996. He had, however, been playing tennis all summer when tested in September 1995 and September 1996. PersCurr = people with whom AM currently plays tennis; PersOld = people with whom AM used to play tennis; FamCurr = currently famous tennis players (Boris Becker); FamOld = tennis players famous in the past (Mo Connolly).

FIG. 2c.   MS's performance on the surname–first name matching test. PersCurr—Bowls = people with whom MS currently plays bowls; FamCurr—Bowls = currently famous bowlers (Richard Corsie); Family/Friends = friends and family of MS; FamCurr—Celebrities = currently famous celebrities (Bill Clinton); FamOld—Celebrities = celebrities famous in the past (Marilyn Monroe).
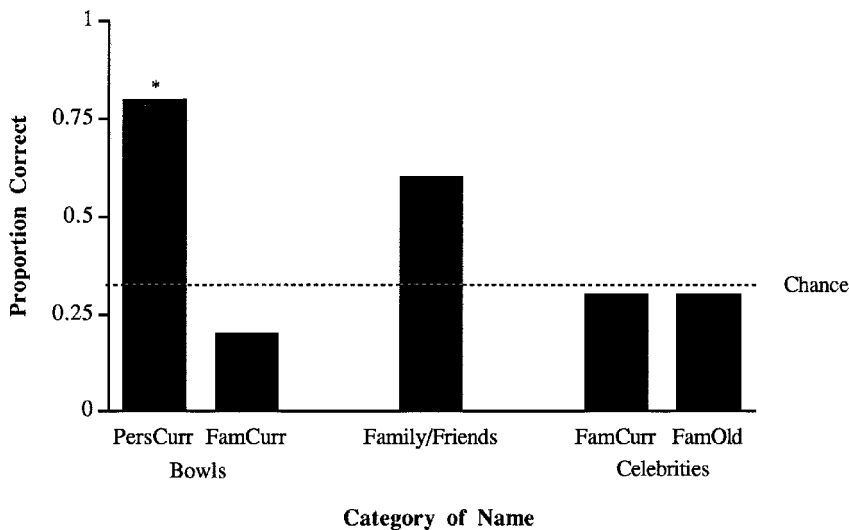
she saw her friends: If she saw someone at least once every 2/3 weeks she almost invariably matched the first name with the surname correctly.

There was a further interesting result in this experiment: AM's performance on the personal and current tennis names was better when he was actually playing tennis. In May 1996, when AM could only match 1/5 of the names, he had not played tennis since the end of the previous summer. Later that year, in September, after a summer of playing tennis again, he correctly matched all the names. This result is difficult to interpret, however, because, to a lesser extent, a similar pattern was seen for the famous past tennis names. In September 1995 and May 1996 AM performed below chance on this category. In September 1996, AM improved, scoring 7/10.

These results raise an important issue: Can exposure to the media also influence the ability of a patient to perform first name to surname matching tests? If the answer to his question was yes, we would have expected AM to show better performance on the currently famous tennis and the currently famous golf names as we know that during the summer of 1996, AM was watching current tennis and golf competitions on television. Although his performance on the famous golf names category was the predicted "U" shape, his score in September 1996 was not significantly above chance. More to the point, there is no plausible explanation (at least in terms of media exposure) for the improvement AM showed on the famous past tennis names. Overall AM

showed little evidence of media exposure on his ability to match up a celebrity first name with its corresponding surname. So, at least at this point, one has to be cautious with the interpretation that the "U"-shaped curve for personal current tennis names does reflect AM's personal involvement in the sport.

There are other studies that suggest that media exposure can have an impact on the ability of a patient with semantic dementia to perform familiarity judgements. Five patients with semantic dementia were asked to point out the famous celebrity name from amongst four proper names (Hodges & Graham, in press). Four patients were better at selecting names from the current time-period, compared with the other three time-periods (1950s, 1980s, and early 1990s). They were unable to produce any information about the names that they had correctly selected.

It should be noted, however, that in Snowden et al.'s (1994) study and the one presented here, first-hand autobiographical experience was significantly more influential than media experience. This difference probably reflects the fact that understanding events portrayed on the television must be exceptionally difficult for patients with semantic dementia. It is highly likely, therefore, that the experiential quality of television has significantly less impact than more direct autobiographical experiences. Furthermore, experienced events in which one is taking an active part must have an emotive quality quite different from that experienced when watching sport on television.

Experiment 2: Identification of People's Names

In this experiment, AM, MS, and the control subjects were asked to provide as much information as possible about the names used in Experiment 1. As for the first experiment, the names were presented in both a written and oral format, and the order of presentation was randomised.

The control subjects (bowls players and golfers) produced correct informa-tion for all the names: for example "Seve Ballesteros"—"Spanish golfer, next time Ryder Cup captain"; "Sam Torrance"—"Scots golfer, first to use special putter"; "Stefan Edberg"—"Swedish tennis player, just retired", "Steffi Graf"—"Number one tennis champion, German, tax problems", "Margaret Johnson"—"Lady indoor bowler"; "Tony Allcock"—"English bowler, fair, chews gum."

The performance of the controls was in stark contrast to that of AM and MS: AM produced information about two items (out of a total of 60) when tested in November 1995. These were both from the personal golf category and AM's responses were as follows[2]:

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[2]The names of all friends and places have been removed from the patient transcripts to protect confidentiality.

1. Golfer (seen three times a week): "man in (place), my doctor."
2. Golfer (seen once a week): "there's a (name) in (place), he'll be about 69 now, plays golf occasionally, my wife plays with his wife, we go to them and they come to our house."

Whereas the second, quite detailed, description was correct, the first response was wrong: AM's wife confirmed that the friend was not their doctor. AM was given the same names to define a further two times (in May 1996 and September 1996): On both these occasions he failed to produce any identifying information.

MS performed slightly better on this test than AM, supplying information for 5 out of the 50 names. The responses (four from the personally relevant bowls category and one from the friends category) were:

1. Bowls player (seen weekly): "she's on her own, lost her husband a long time ago."
2. Bowls player (seen every 2/3 weeks): "somebody at our bowls?"
3. Bowls player (seen every 2/3 weeks): "she's also bowling, she doesn't live in the village, but in the other place."
4. Bowls players (seen every 2/3 weeks): "she's one of my friends."
5. Friend (seen daily): "across the road."

It is clear that MS has little semantic information about the people that are her bowls partners, many of whom are close friends. This is particularly striking as in many instances she correctly matched up the first name with the surname in Experiment 1. Although a total of 14 items were correctly matched over the 2 personally relevant categories (current bowls friends and family), she was unable to produce any useful information for 9, most often responding, "don't know"; "I seem to know the name, but don't know what she does"; "do I know this name?" Furthermore, the information she did produce for the five items was exceptionally poor. It might be argued that this reflects her extremely impoverished vocabulary, but it can be seen from the transcripts that she possesses sufficient language output abilities to permit much more detailed description of friends, albeit with limited use of content words.

Discussion

Despite both patients showing an effect of autobiographical experience on surname–first name matching, neither patient was able to produce information about people with whom they were currently playing golf or bowls. This was especially true for AM. MS managed to identify 4/10 bowls friends, yet it was obvious that the information she possessed about those friends was profoundly impoverished. These results suggest that, at least in these two patients, auto-

biographical experience is having no significant impact on the integrity of representations relating to current friends within the person-specific semantic store. These results are strikingly different from those found by Snowden et al. (1994). In their paper, the 5 patients managed to produce information for an average of 6 out of 10 names from the current personal category. They were more impaired on the 10 names from the past personal category, producing information for less than 2 of the names.

Current computational models of long-term memory predict that patients with semantic dementia should be able to retrieve autobiographical memories from the recent past. As suggested in the Introduction, we believe that any accompanying "semantic facts" are an inherent part of the autobiographical memory. For example, a patient with semantic dementia (GCB; see Hodges & Graham, in press) was asked to describe a "swan" from the spoken word. Part of the definition was as follows:

> Oh in (place), when I take (name) to the station there, it's quite incredible, there's a lovely river there, lots of swans there and masses of people I see taking bags with bread, they like bread, and they throw it into the river and then the swans go pick, pick, pick, pick, masses of them come, so they throw little bits of bread.

This story, clearly autobiographical, contains some information about swans that could be considered as semantic. The fact that it does so does not, however, mean that the patient has access to a long-term store of integrated semantic knowledge. We would like to argue, instead, that the patient provided the semantic information (swans have to do with rivers, they eat bread, people watch them) by recalling a recently experienced event. There was some evidence that the definitions produced by Snowden et al's (1994) patients were of this type. They report (pp. 273–274):

> The quality of responses in the semantic group is worthy of note. For the majority of the celebrity names, patients denied knowledge. However, for those celebrity names reported as familiar, patients invariably provided an interpretation within an autobiographical context (e.g. Margaret Thatcher: Margaret Thatcher, is that Margaret and Reg, who we go for a drink with?; Nelson Mandela: That must be one of Bill's friends. I think he works with him).

Although Snowden et al. do not provide examples of the definitions produced by their patients for friends, it is reasonable to assume that if their patients were producing these autobiographically based descriptions for celebrities, they were also producing similarly autobiographical information about personal friends. Furthermore, in Snowden et al's (1995) paper, WM almost always produced autobiographically constrained definitions to the nouns and phrases she had to define. We also suspect, from the celebrity definitions, that

the definitions produced by Snowden et al's (1994) patients for friends were impoverished and quite unlike the factually accurate definitions normal subjects would produce. The very impoverished nature of AM's and MS's definitions supports the idea that the only information available to the two patients was through recent autobiographical experience: They seem unable to access any of the person-specific information (presumably stored within a person-specific semantic store) which normal controls would use in such definitions (for example, details about occupation, nationality, achievements, personality, family, etc.).

In the Introduction, we argued that Snowden et al's (1994, 1995) results reflected the distribution of neuroanatomical damage in semantic dementia. The loss of semantic memory and of more distant autobiographical memories reflects, we suggest, the atrophy to the temporal neocortex. The preservation of recently experienced events, however, is dependent upon the hippocampal complex, an area of the brain that is relatively preserved, at least initially (see Harasty, Halliday, Code, & Brooks, 1996), in semantic dementia (Graham & Hodges, 1997). Recently experienced events may contain fragments of semantic-like information, but it is important to distinguish these from true semantic facts, which have no temporal-spatial characteristics and are permanently represented in the temporal neocortex. In summary, we believe that *recently* acquired (hippocampally dependent) and *previously* acquired (neocortically dependent) semantic knowledge are not affected equally by autobiographical experience.

The critical test of this hypothesis is to investigate our patients' knowledge of information that we know was encoded in the past: Semantic information that we will refer to as pre-existing (as opposed to semantic information encoded as part of an autobiographical experience). We tested this hypothesis by giving AM and MS a number of tests about golf and bowls. We also used tests of tennis (AM played tennis once a week in the summer) and football (AM had been a keen footballer up until his thirties).

Experiment 3: The Integrity of Semantic Knowledge about Golf and Bowls

A number of different tests were designed based on terms specific to golf and bowls. The items used in the tests are given in Appendix B.

Definitions to Words Used in Golf and Bowls

Twenty-five words were selected that are commonly used in each of the two sports (e.g. Golf: "bunker," "caddie," "birdie," "driver," "air shot," "green," etc.; Bowls (from indoor, outdoor, and crown bowls): "skip," "rink," "woods," "toucher," "jack," "wick shot," etc.). The patient was presented with each of the 25 words one after each other. The words were written on cards and read

out aloud to the patient. The instructions were as follows, "I am going to show you some words. Can you tell me as much as possible about their meaning." The patient was not told that the words were from a specific category until they had gone through all the items.

None of the control subjects had any difficulty with this task. The golfers scored, on average 24.5 (SD = 1) and the bowls players scored 22.7 (SD = 1.3) out of a possible 25[3]. The definitions were detailed and accurate: "fore"—"shout out if your ball is going in the wrong direction, towards people"; "Matchplay"—"when playing for holes, rather than over the whole course. It doesn't matter how many strokes for a hole"; "wick shot"—"use someone else's wood to ricochet off towards the jack"; "ditch"—"space at the end of the rink; also sometimes at the side."

By contrast, AM was unable to define any of the golf words correctly. A number of his responses were as follows:

> Putt: "Putt, gosh, can you say for me what a putt is?"
> Hole-in-one: "Hole-in-one, there's several holes in one (points to the carpet)."
> Bunker: "I always do the bunker outside, doing things, so I've got loads of bunkers all over the place (indicates outside in the garden)."
> Bogie: "There's lots of bogies, just like the thing where (name) does them for our food, what's that again, that place where she has it for the food, food."
> Tee: "I don't know what t, e, e, is at all."
> Irons: "Irons, the irons (pause), well loads of stuff with all our food here, irons might be some of them."
> Niblick: "Niblick, niblick, niblick, I don't know niblick at all."

When AM was told that all the words were to do with golf, he disagreed, responding, "Well, they'll probably just be one or two or so in golf." In fact, out of the 25 items, AM subsequently categorised only 8 of the words as being related to golf. For 11 items he was adamant that they were not to do with golf, while for the remaining 6 he said "don't know" or provided an incorrect description. One interesting definition was to the word "irons":

> *AM*: It's part of my golf.
> *KG*: What is it?
> *AM*: I normally have three of them, and their names for me is 1, 3, 5 irons.
> *KG*: Do you have any others?
> *AM*: No, I just use the 1, 3, and 5 irons, the other stuff is a different name.

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[3] The bowls controls had significant difficulty with three words ("footer", "cobbing" and "the guard"). "Footer" and "Cobbing" are used in crown bowls, which is played by MS, but not by the control subjects used here. "The guard" (a blocking bowl) is more commonly called a "blocker" in Cambridgeshire.

Later AM demonstrated this by taking the experimenter to see his golf clubs. He pulled out his driver and his woods, repeating that he used the 1, 3, and 5. It was clear that AM was unable to distinguish, at least verbally, between the two different types of clubs (woods and irons).

The majority of MS's responses to the 25 bowls terms were "don't know." She only managed to produce one definition, which was to the word "rink": "well which ever rink you happen to be on. You were on rink nine today weren't you (to her husband)?" Some other examples of MS's definitions are as follows:

Skip: "To go over something."
Ditch: "Something for sitting on?"
Toucher: "Something you're going to have to put a toucher on, whatever you happen to be."
Footer: "Something to do with your feet? You're foot?"
The draw: "What would you use that for? Mmmm. Don't know."

Like AM, MS did not believe the experimenter when he told her that the words were all bowls terms, responding, "toucher, something to do with bowling? No. Oh . . . but what does it mean then?" When asked about the game she had watched her husband play on the morning of the testing session, she commented, "I was watching him . . . he was on rink two and the others on rink 4. They had lost . . . but they normally win . . . but as I say, you never know what will happen until the final end." In this response, there were two appropriate bowls words: "rink" and "end."

Pick the Sporting Word

For patients like AM and MS, describing the functions of a word used in sport is quite a linguistically demanding task. It is possible, although unlikely considering the severely impoverished nature of their performance, that they were impaired on the definitions test because of their anomia. A further, less taxing, test measuring knowledge of sport was given to both patients. Fifteen words from four sporting categories (tennis, football, golf, and bowls) were selected. AM was given the tennis, football, and golf categories, while MS was given the tennis, football, and bowls categories. Each target item was paired with two distractor items. These distractors were similar words from different sports (for example, "skip" was matched with "fly-half" and "goalie"; "ball-boy" with "cox" and "prop"; "iron" with "raquet" and "cue"; "crossbar" with "wicket" and "basket"). The patient was presented with the triads (both written and spoken) and asked to pick the words that corresponded to a particular sport. All 15 items from each of the 4 categories were presented together. The categories were given in the following order: (1) golf/bowls; (2) football; (3) tennis.

Overall, the control subjects were almost perfect on all the tested categories. The control golfers scored as follows: Golf: 15 (SD = 0); Football: 14.5 (SD = 0.6); Tennis: 15 (SD = 0). The control bowls player made slightly more errors (mainly to crown bowls items, which are unfamiliar to Cambridgeshire bowls players) yet still performed relatively well on the tests: Bowls: 12.3 (SD = 1.3); Football: 13 (SD = 1.6); Tennis: 14.8 (SD = 0.5).

Figure 3a shows AM's performance on this test, which was given to him twice, in September 1995 and in February 1996. A "*" above a column refers to a score which is significantly different from chance. This was calculated using 95% confidence intervals. On all the tests AM was significantly worse than the control subjects, who scored at ceiling in all three categories. There was also no evidence that AM was significantly better at golf than the other two sports. In September, AM was able to correctly select just over half of the golf items (8/15). He performed slightly better on the football items (selecting 10/15), but scored at chance on the tennis items (4/15). Binomial proportion analyses confirm that AM, while showing no significant difference between his score on golf and football ($z = 1.5$), was significantly better on golf and football than tennis (Golf vs. Tennis: $z = 2.99$; $P < .001$; Football vs. Tennis: $z = 4.4$, $P < .001$). Six months later, he showed no difference in his scores on the tennis and football items, but had now declined on the golf stimuli (5/15). Analyses confirmed no significant difference between AM's performance on the golf and the tennis items ($z = 0.8$). He was still significantly better on the football items compared with both the tennis and golf (Golf vs. Football: $z = 3.6$; $P < .001$; Tennis vs. Football: $z = 4.4$; $P < .001$).

As with AM, there was no support for the hypothesis that MS was significantly better on the bowls version compared with tennis and football. MS performed at chance level on the tennis stimuli (see Fig. 3b). She was much better on the football items (scoring 8/15), but did less well on the words relating to bowls, scoring close to chance (6/15)[4]. Overall, MS's performance on the football was not significantly different from her performance on the bowls ($z = 1.5$), but she was worse on the tennis compared with the football stimuli ($z = 2.2$, $P < .05$).

Completion of Golf Sentences and Golf Courses

Two further tests tapping semantic knowledge about golf were specially designed for AM. In the first, the completion of golf sentences, 15 sentences about golf were created. One word was missing from each sentence. AM had

[4]Another patient with semantic dementia, who is also a keen bowls player, was given this test. Like MS, PS scored at chance on the items from the bowls test (5/15). She is not included in this paper because she did not wish to be tested further and it was not possible to give her the other tasks.

FIG. 3a.   AM's performance on three sporting categories (golf, tennis, and football) when asked to pick a word from each sporting category. The target word was presented with two distractor items (words used in other sports).
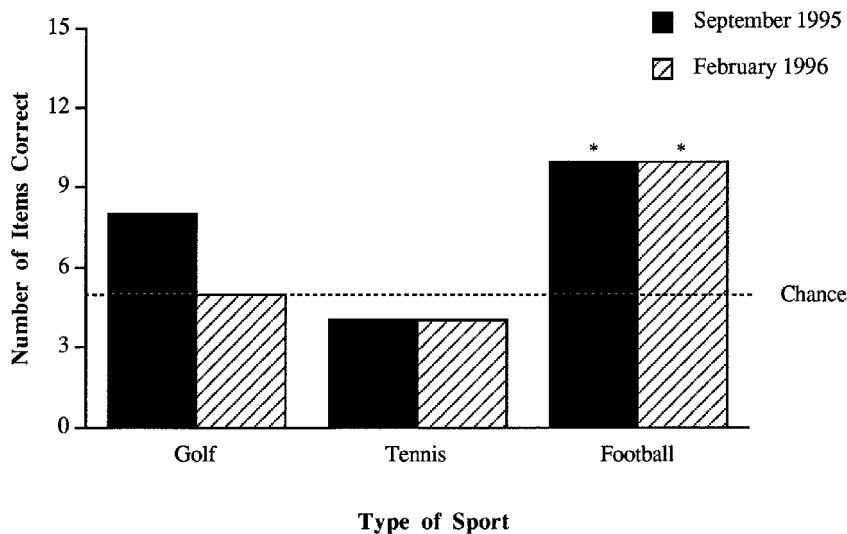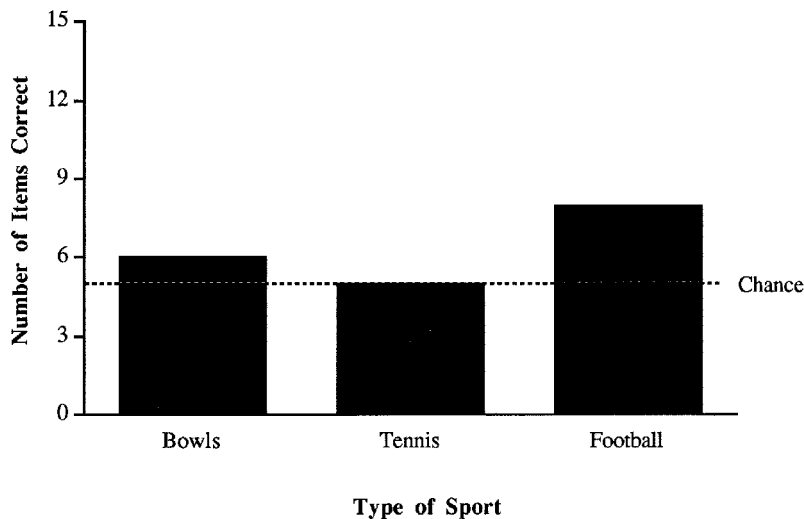

FIG. 3b.   MS's performance on three sporting categories (bowls, tennis, and football) when asked to pick a word from each sporting category. The target word was presented with two distractor items (words used in other sports).

823

to select an appropriate word from three possibilities (all golf terms). For example, "In a slice shot, the ball flies to the ___." (left, straight ahead or *right*); "The man was pleased when his ball was ___." (in the bunker, in the rough or *on the green*). Although AM showed no difficulty reading the sentences or the candidate words, he only scored 3/15 on this task (less than chance). The four control golfers were virtually perfect: three scored 15/15 and one 14/15.

A second test was designed based on one included in Snowden et al.'s (1994) paper. Snowden et al. had asked two of their patients to point out places on an outline map of the United Kingdom (UK). A similar task was used with AM: On one outline map (of the UK) he was asked to note down the location of 21 cities and islands (Glasgow, Isle of Wight, Norwich, etc.). On a second map, he was asked to note down five areas (e.g. Norfolk Broads, Lake District, etc.). On a third map, he was required to place 10 famous golf courses (Gleneagles, Turnberry, Royal Birkdale, etc.). It should be noted that AM has played golf on all of these and, at the time of testing, played regularly on two. If experience was helping maintain semantic knowledge, AM should have been better at matching the golf courses than any of the other cities, islands, or areas.

The three maps are shown in Fig. 4. Figures 4a (Map 1) and 4b (Map 2) show that AM correctly placed 4 out of 20 cities/islands and only 1 area, the Lake District, respectively. The control golfers found this task quite difficult, yet still managed to place 18.3 (SD = 1.0) cities/islands and 4.5 (SD = 0.6) areas correctly. AM was equally poor at placing golf courses: Figure 4c (Map 3) reveals that AM was unable to place any of the golf courses accurately, despite the fact that he plays regularly on 2 of the famous golf courses included in our list of 10. The only golf course plotted on his map (Royal Lytham) was placed on the correct side of the country, but too high (within the Lake District). The controls managed to place 6.5 (SD = 2.4) golf courses correctly. Figure 4d (Map 4) shows the location of all 10 golf courses as plotted by one of the control golfers.

Discussion

Neither AM nor MS showed significantly better knowledge of golf and bowls, respectively, on our tests of semantic knowledge (definitions, pick-the-sport-ing-word, completion of golf sentences, and placing of golf courses on a map). In fact, it was striking that both patients performed so poorly considering the degree to which each patient plays and experiences their particular sport. These results support the hypothesis suggested in the discussion after Experiment 2. We proposed that autobiographical experience did not have any impact on pre-existing semantic representations within the temporal neocortex. This view explains why our patients do not show any superior knowledge of golf/bowls compared to other sports and why they are poor at producing detailed "general"

(a) Map 1.

FIG. 4. AM's performance when asked to place (a) cities and islands (Map 1); (b) areas (Map 2); and (c) golf courses (Map 3) on a map of the British Isles. (d) Shows the correct location for all the golf courses, as placed by one of the control golfers (Map 4). Maps 2, 3 and 4 appear on the pages following.

825

LAKE
DISTRICT

(b) Map 2.

(c) Map 3.

827

(d) Map 4.

descriptions about people with whom they play sport. These results have a number of important theoretical implications.

There is no evidence to support the hypothesis suggested by Snowden et al. (1994, 1995) that autobiographical experience is maintaining and supporting all semantic knowledge. More specifically, although patients like AM and MS may produce superficial "recent" semantic information as part of a "recent" autobiographical episode (presumably via temporary representations in the hippocampus), older semantic knowledge (which is represented in the temporal neocortex) is not influenced by autobiographical exposure. Snowden and colleagues did not discuss this important, time-based, distinction in their paper. It seems to us, though, that it is crucial to consider "recently" acquired knowledge as very separate from "older" acquired knowledge, particularly as current models of long-term memory suggest that different neuroanatomical structures subserve these time-periods. As mentioned previously, it is not possible to tease apart semantic and autobiographical aspects of memory in the recent time-period: Semantic information, at this stage, is an intrinsic part of autobiography. This hypothesis explains why patients with semantic dementia are better at retrieving both semantic and autobiographical knowledge from the recent time-period (Graham & Hodges, 1997; Hodges & Graham, in press).

A further implication concerns the ability of MS to produce the words "rink" and "end" in spontaneous speech, but not to define either of these terms correctly. MS's definition of the word rink was based on a description of her husband playing bowls the morning prior to her being tested. This observation raises the possibility that MS had learnt the terms from the morning and could produce them as part of a story. She did not really understand the words, however, and we suspect, that if she was tested a few days later, that she would no longer be able to produce the two words.

Summary

The results from the experiments are summarised in Table 2.

TABLE 2
Summary of Whether AM's and MS's
Performance on the Tests Used in This Study Was
Affected by Autobiographical Experience (see
Text for Details)

Test	AM	MS
Surname-first name matching	✓	✓
Definitions to a proper name	✗	✗
Definitions to sporting terms	✗	✗
Pick-the-sporting-word	✗	✗
Complete the golf sentences	✗	Not tested
Locating golf courses in the UK	✗	Not tested

GENERAL DISCUSSION

It was found that autobiographical experience influenced a patient's ability to perform familiarity judgements. As demonstrated by Snowden et al. (1994), this effect was greater for people who were personally and currently relevant. Matching of names of famous celebrities and friends from the past was exceptionally poor. Theoretically, these results suggest that autobiographical experience can have an impact on familiarity judgements about proper names. In current models of face and name processing (see Valentine, Brennen, & Brédart, 1996), presentation of a face or a name activates a store of face recognition units (FRUs) or a set of name recognition units (NRUs), respectively, which in turn activate semantic information about that person. This activation occurs via a set of multimodal nodes called person-identity nodes (PINs). It is thought that familiarity judgements (i.e. recognising whether a name or face is familiar) takes place at the level of the PINs. Based upon this model, we would argue that repeated autobiographical experience acts by refreshing PINs, a hypothesis that predicts that names heard often will be much easier to recognise than names heard only infrequently.

Could a similar, implicit, impact of autobiographical experience help support vocabulary production? Although the effect of autobiographical experience on vocabulary was not tested directly in these experiments, it was clear that MS, at least, was usually unable to produce any words related to bowls (see the transcript in the case-history), although on one occasion she did produce two words (rink and end) one afternoon after watching her husband play bowls.

We would predict that any impact of autobiographical experience within the phonological lexicon would be less than that seen for proper names. Proper names are typically unique and, unlike most words, are special because there is a first name and a surname. Furthermore, proper names are most often used when the face is also present: A fact that leads to the activation of the appropriate PIN. The phonemes which combine to create common nouns (and other words) are rarely unique to one word: It would be difficult for autobiographical experience to benefit one word more than another.

Another possible explanation for Snowden et al's observation that patients with semantic dementia can produce autobiographically relevant vocabulary could be related to differences between individual cases (i.e. maybe some patients can relearn and use words that they hear often). In fact, WM, who is described in Snowden et al. (1995), was able to relearn names of people and, presumably, new vocabulary. There is accruing evidence (Knott, Patterson, & Hodges, in press; Graham, Patterson, & Hodges, 1995; in press) that some patients with semantic dementia are more anomic than others, possibly reflecting the relative degree of left and right temporal lobe involvement in the disease. Patients with predominant left-sided atrophy appear to have a degree of anomia that is over and above their semantic deficit, due to involvement of additional

post-semantic processes implicated in word production. By contrast, patients with less left-sided atrophy may be less anomic and, therefore, may be able to learn and produce unusual vocabulary directly related to autobiographical experience, in spontaneous speech. In support of this view, performance on the Warrington Recognition Memory test (Warrington, 1984) is often dependent on the degree of left vs. right temporal lobe damage: Patients with right temporal lobe damage tend to be worse on the faces component than the words component. Patients with more left-sided temporal damage show the opposite pattern of performance (Graham, Becker, & Hodges, 1997).

In support of this hypothesis, neither of our two patients, who both have predominantly left-sided temporal lobe atrophy, were able to produce terms relating to golf or bowls in their spontaneous speech, and on standard tests of picture naming, both were exceptionally anomic. If Snowden et al.'s (1994, 1995) patients had predominantly right-sided atrophy, this may explain their ability to produce unusual, low-frequency words in spontaneous speech. Snowden et al. (1994) did not describe each patient's score on picture naming tests: The performance of three patients is reported as approaching "floor level," while two other patients named 6/60 and 1/60 on the Boston Naming Test (Kaplan, Goodglass, & Weintraub, 1983). Structural brain imaging (MRI) was not reported but functional brain imaging using single photon emission tomography showed asymmetric fronto-temporal abnormalities that were more marked on the left. It seems, therefore, that these patients were roughly as anomic as AM and MS and it is difficult to account for the striking differences in vocabulary production on individual case differences.

Our patients showed no benefit of autobiographical experience on previously acquired semantic knowledge. Both patients were extremely poor at producing information about currently relevant people (golfers, bowls players, and friends) and widely used golf and bowls terms. The fact that MS was able to produce impoverished autobiographical memories about some personally relevant people (but nothing about golf and bowls) must reflect the fact that it is easier to record episodes about people (who are unique and encountered in a variety of places at different times) and that these interactions are qualitatively different from other object and/or animal-based encounters. Furthermore, we believe that the ability of the patient to produce such autobiographical memories is directly related to how often the patient meets a person: MS was better at producing definitions to people if she saw them daily compared with once a month. This "familiarity" effect (a measure of the number of times a patient is likely to encounter a friend) must have an impact on the ability of the patient to produce an autobiographical memory about that person.

The fact that neither patient showed any benefit of autobiographical experience on their knowledge about golf and bowls is difficult to accommodate within the framework of current computational models of long-term memory. Murre (1997) and McClelland et al. (1995) have proposed that learning pro-

ceeds via the neocortex: For example, incoming sensory stimuli activate a set of appropriate representational nodes in the neocortex, which in turn activate links with the hippocampus (Murre, 1997) or result in a compressed memory being stored within the hippocampus (McClelland et al. 1995). Thus the hippocampal trace or index depends upon the presence of appropriate semantic representation in the cortex. It follows that repeated exposure should benefit pre-existing semantic knowledge stored in the temporal neocortex (i.e. AM and MS should have been better at the semantic tasks based on golf and bowls compared with the other sports). Our results are not explained by these models and it is not clear how to resolve the lack of benefit of autobiographical experience within the frameworks proposed by Murre (1997) and McClelland et al. (1995). One possible interpretation of the results described here is that the hippocampal complex receives direct inputs from higher-order sensory cortices as well as from regions concerned with the representation of long-term semantic memory. In the normal functioning brain, these systems would operate in concert. In semantic dementia, the progressive breakdown of long-term memory leads to an increasing reliance on input from sensory areas. This hypothesis predicts that patients with semantic dementia will be able, at least initially, to form new episodic memories (i.e. novel conjunctions of sensory information) but that these memories cannot be integrated, via consolidation, into long-term semantic or autobiographical memory systems. Thus, the hippocampal complex is able to operate as a temporarily limited memory system that can store new episodes. Such episodes may contain isolated semantic-like facts that are highly autobiographically constrained.

Although the results from this study, and those of Snowden et al. (1994, 1995)[5], suggest a crucial interaction between autobiographical and semantic memory in the current time-period, it is important to note that this interaction is probably more complicated than a simple distinction between recently learnt and previously learnt semantic knowledge. Further studies that address the integrity of semantic knowledge in recent and more distant time-periods will help clarify this issue. For example, there have been few studies of implicit memory in semantic dementia: We do not know, therefore, whether AM and MS might have shown preservation of "implicit" knowledge of golf and bowls that was superior to their "implicit" knowledge of other sports (e.g. football). The fact that for a period of time after they were tested both patients still

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[5] Since our paper was submitted and accepted, Snowden and colleagues have published another article on interactions between semantic and episodic memory in semantic dementia (Snowden, Griffiths, & Neary, 1996). In their new paper, they discuss the observed preservation of *current* information for knowledge of celebrities, understanding of current versus old monetary systems, and autobiographical memory. Although we were not aware of these findings prior to submission of our study, we acknowledge that some of our criticisms may now have been addressed by Snowden et al.'s (1996) paper and, therefore, draw readers' attention to the article.

managed to play golf and bowls at a reasonably good level suggests that they may have possessed some implicit knowledge of these sports. An alternative hypothesis is that performance on the golf course and bowls rink was less affected by the loss of semantic knowledge because (1) there were many more contextual clues available to support performance, and (2) the many years of playing each sport resulted in a strong automatic procedural component to AM's and MS's playing of golf and bowls, respectively. Although these procedural skills would allow the patients to seem quite accomplished at their selected sport, they would not be useful on a test in which AM and MS had to differentiate between a golf/bowls word and two other sports words (as in the pick-the-word test).

In conclusion, we propose that recent autobiographical experiences are encoded and stored via the hippocampal complex in patients with semantic dementia. These experiences may contain fragments of semantic-type information that are constrained by autobiography (in the sense that a patient could recall temporal-spatial aspects of the learning experience) and tend to be reproduced as part of an autobiographical memory. Our permanent store of integrated semantic facts and long-term personal memories relies upon distinct neuroanatomical regions (infero-lateral temporal lobes) that are severely compromised in semantic dementia. Current autobiographical experience appears not to help maintain such general and person-specific semantic knowledge. It does, however, have a particular role in the preservation of person-identify nodes that allow subjects to make correct judgements about the familiarity of personally relevant names. In the two patients described here, their ability to match a surname with a first name had the quality of implicit memory in that they had no apparent awareness of the correctness of their choice and were unable to access knowledge about the people.

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APPENDIX A

The full transcript of the conversion about bowls between Matt Lambon Ralph (E), MS, and MS's husband (R).

E: So what do you do when you go bowling?

MS: Well you see who is there

E: Okay, so then what do you do?

MS: Well, you wait and see how many people, . . .can get together

E: So how many do you have in a team?

MS: Well, it just depends on what is going on; sometimes you have two, sometimes three, sometimes four

E: Right, So have you got a team together and you go out into the green. What do you do first?

MS: Well you start

(*R*: You put a mat down)

E: Right, so you put a mat down and then what do you do?

MS: Well you send off the . . . err

(*R*: Jack)

MS: The jack, and depending on how far it has gone, mmm, the ones at the top there, mm, has got to put it exactly opposite the back bit and the front bit

E: Right. And then how many bowls do you have each?

MS: It depends what's going on. It depends what on earth you're doing.

E: Right

MS: We were down there about a month ago and, . . . err, there were two females who only had two at that time, because that was the thing that they were . . . against that day

E: So the person who is in charge, of your team, what's their name? What are they called?

MS: Don't know

(*R*: The person at the top end that centres the jack)

MS: Well, do we give them a name?

(*R*: Yes)

MS: The one at the top there?

(*R*: Mmm)

E: The skip

MS: Oh I'm sorry I thought you were talking about someone else

E: So how do you score in bowls?

MS: Score?

E: Yes, how do you score points?

MS: Well, if there's four, the third one, then who is the one who has a look around and sees whether they have got one, two or three, . . . they have to look and see

E: So do you get one, two or three?

MS: Well if the other one, you are against, hasn't got anything near that three, then you have got three.

E: Good. So how many points do you need to win the game?

MS: Well sometimes, you only have one point to win the frame. It just depends on what's going on.

E: Right, so do you play for a certain length of time?

MS: Well, yes, two hours

(*R*: That's indoors. Outdoors it's different—there's so many ends)

E: So if you are outdoors, Mmm, what's an end? What does an end mean in bowls?

MS: What do you mean? I don't know what you're talking about.

E: Okay, so you roll up your jack and everyone plays their bowls and you score one, two or three — that's an end. And then you start again.

MS: Yes

E: Okay, how many ends do you play, outdoors?

MS: Well about . . . err, it tells you sometimes, err . . ., mm . . ., sometimes it's about 14

E: So how many do you play?

(*R*: 21)

MS: Sometimes it goes to the 20s

(*R*: 21)

MS: Right, that's good

(*R*: Sometimes in the evening, in June, no May, it's 18 because it gets too dark)

APPENDIX B

The items comprising the tests described in Experiment 3.

Definitions to Words Used in Golf and Bowls

Golf: Texas scramble, putt, drive, slice shot, hook shot, chip shot, airshot, hole-in-one, fairway, bunker, caddie, birdie, eagle, albatross, bogie, matchplay, fore, tee, rough, irons, niblick, sandwedge, tee peg, Stableford, dormie.

Bowls: cradle grip, rest shot, the guard, marker, skip, ditch, wick shot, rink, line, end, trail shot, mat, delivery, head, woods, toucher, length, dead end, set a mark, footer, the draw, bank, claw grip, yard on shot, number 2.

Pick the Sporting Word

Golf: chip shot, pitch, slice shot, bunker, iron, putter, hole-in-one, green, drive, matchplay, tee peg, caddie, airshot, birdie, hook shot.

Tennis: deuce court, stop volley, ace, ballboy, van-out, lob, footfault, hard court, volley, baseline, let, tramlines, tie-breaker, sets, net.

Football: crossbar, corner-flag, throw-in, five-a-side, centre-half, dribble, goal, first touch, defender, pitch, own goal, the area, striker, penalty, one-two.

Bowls: claw grip, the draw, wick shot, skip, footer, triples, stopper, rink, toucher, woods, jack, ditch, trail shot, the guard, cobbing.